METHOD AND PLANT FOR CONTINUOUS DIRECT CASTING OF METAL STRIP

The invention relates to the continuous casting of metals. It relates more precisely to the continuous casting of metal strips of narrow thickness directly from a liquid metal using the twin roll casting method or generally between cooled, moving walls.

The twin roll casting method consists of casting a metal strip, in carbon steel for example or stainless steel, Fe-Ni or Fe-Si alloy or other ferrous or non-ferrous alloys, through the solidification of liquid metal on the cylindrical side walls of two rolls rotating in opposite directions and cooled in the inside. Two solidified "skins" are formed on these walls and they are caused to be joined substantially at the "neck" i.e. the point where the space between the walls is narrowest and substantially equal to the thickness of the strip it is desired to cast (in the order of 1 to 10 mm, generally 3 to 5 mm).

In numerous cases, the solidified strip leaving the casting rolls then undergoes hot rolling in one or more steps in one or more rolling stands arranged in line with the casting rolls. It is only after this hot rolling (and optionally other metallurgical operations such as reheating and/or controlled cooling) that the strip is wound in a reel and shipped to the customer or to other processing stations such as a cold rolling line.

In-line hot rolling makes it possible to obtain spooled, thin strips of steel (and iron alloys in general) having a thickness close to the desired end thickness of the product without having to achieve this narrow thickness directly on leaving the casting rolls (where thicknesses of less than approximately 3 mm are difficult to achieve). It also makes it possible to refine and homogenize the microstructure of the strip.

It is of advantage that the rate of reduction during hot rolling should be as high as possible. However, in practice there is a limitation in this respect in particular on account of the carbon build-up which forms on the surface of the strip between the time it leaves the casting rolls and the time it enters the rolling mill due to oxidation of its surface by the ambient atmosphere.

One remedy for this limitation is to install an inertization chamber between the casting rolls and the rolling mill, in which a neutral or reduced atmosphere is maintained that is low in oxygen. The presence of this chamber however considerably complicates the construction and operation of the continuous casting plant. And even with said inertization chamber it is difficult to exceed a reduction rate of more than around 50 % unless the construction costs of the installation are increased to proportions which would cancel out the

economic advantages of "thin product casting" compared with conventional production methods.

The purpose of the invention is to propose a method and an installation for the continuous casting of thin strips, which gives access under advantageous economic conditions to very high reduction rates during in-line hot rolling.

For this purpose, the subject of the invention is a method for the continuous direct casting of a metal strip, according to which said strip is cast by solidification of liquid metal in an ingot mould with cooled moving walls and said strip is then given in-line hot rolling, characterized in that a product is applied to the surface of the strip as it leaves the ingot mould which leaves a lubricant layer on said surface which subsists for hot rolling of the strip and causes a gaseous release contributing towards protection of said surface from oxidation.

Said lubricant layer may be in a carbonaceous material.

Said product leaving a lubricant layer to subsist may then be graphite.

Said product leaving a lubricant layer to subsist may be a grease containing calcium carbonate.

Said product leaving a lubricant layer may be acetylene.

Hot rolling may be conducted with a reduction rate of at least 50%.

Said liquid metal may be a ferrous alloy.

A further subject of the invention is a plant for continuous direct casting of a thin metal strip, of the type comprising an ingot mould with cooled, moving walls where solidification of said strip occurs and an in-line hot rolling unit for said solidified strip, characterized in that it comprises means for applying a product to the surface of said strip as it leaves the ingot mould, which leaves a lubricant layer subsisting on said surface as it enters the hot rolling unit.

Said moving walls may be the side walls of two rolls rotating in opposite directions.

Said moving walls may be two moving belts.

The plant may comprise an inertization chamber for said strip between its exit from the ingot mould and its entry into the hot rolling unit.

As it will have been understood, the invention consists of applying a product to the surface of the strip as it leaves the casting rolls (product initially in a solid, liquid or gaseous state) which leaves a lubricant layer subsisting on the surface of the strip up until the time the strip enters the hot rolling mill. The lubricant effect during this hot rolling makes it possible to achieve reduction rates of 50 % or more in a single pass.

Evidently, it could be considered to conduct one or more rolling passes thereafter (optionally separated by intermediate reheating or cooling).

Under these conditions, it is possible to consider obtaining spooled strips having a thickness of 1.5 to 1 mm, even less, from cast strips having a thickness of 3 to 5 mm on leaving the casting rolls, hence conforming to usual practice in this respect. The hot rolled products so obtained may even in some cases substitute for products of same thickness whose preparation required cold rolling. At all events, the possibility of achieving very high reduction rates during hot rolling gives rise to new metallurgical possibilities drawing benefit from the highly rolled strips thus obtained.

The obtaining of these very high reduction rates under satisfactory conditions of strip surface quality can only be contemplated if the surface of said strip is free or almost free from carbon deposit at the time it is rolled. From this viewpoint the invention is also particularly advantageous. The layer of product intended to form the lubricant acts as a protective layer against atmospheric oxidation. Also, cracking of the product at the time it is applied to the strip and in the instants following thereafter results in the formation of gases which act to make the strip surface inert by drastically reducing the surrounding oxygen concentration. If an inertization chamber is used, these gases will remain therein and themselves take part in surface inerting, which makes it possible to reduce the added quantities of neutral or reducing gas. In the most favourable cases, it is even possible to eliminate the inertization chamber, the release of gases derived from the product on heating and decomposed by the heat of the strip surface proving sufficient to ensure the desired low oxygen concentration in the vicinity of the strip surface.

In practice, the strip leaving the casting rolls takes a few seconds to arrive at the in-line hot rolling unit and has a temperature in the region of 950 to 1050°C. The characteristics of the applied product must therefore be such that it is able to subsist in effective form, for example in the form of a carbonaceous material on the surface of the strip as it enters the hot rolling unit, and is able to produce protective gases, due to its cracking, at least during the instants after the time the strip leaves the casting rolls. It is during these instants that the strip is hottest and hence the risk of carbon deposit is highest. If no inertization chamber is used, it is preferable for this cracking to be continued as far as the hot rolling unit. The type of product and the quantity applied to each surface of the strip must be chosen accordingly.

Among the products which may be used within the scope of the invention, graphite powder may be cited or a grease containing up to 50 % calcium carbonate. On account of its

relatively high viscosity this latter type of product may be particularly suited for coating the strip, in particular over the portions of its travel during which it is vertical or on its passive surface as it enters the rolling machine.

As a general rule, advantageous use may be made of a product which, after cracking, leaves a carbonaceous residue on the surface of the strip ready to be rolled.

One way of obtaining this carbonaceous residue may, for example, consist of blowing acetylene onto the strip surface. Its combustion according to the reaction:

$$2C_2H_2 + 2O_2 \rightarrow 2C + H_2O + CO + CO_2 + H_2$$

produces graphite which then constitutes the lubricant layer which the invention is intended to obtain. This reaction also produces hydrogen which causes the atmosphere to be a reducing atmosphere.

The invention has been described under its application to the casting of thin metal strips between twin rolls. But is also possible to consider its application to other types of thin strip casting installations, for example to the casting of thin strips of relatively wide thickness, in the order of 5 to 10 mm, between two cooled, moving belts.